WORKPLACE SAFETY AND HEALTH DIVISION

GUIDANCE ON FALSEWORK/FORMWORK

Workplace Safety and Health Division
1000 - 330 St. Mary Avenue
Winnipeg, Manitoba
R3C 3Z5
Tel. No. 945-3446

February, 1987

PREFACE

This information package is prepared to brief engineers, contractors and all those who are involved in the design, erection and use of falsework, including formwork, on the key points of the new construction safety regulations (MR 189/85) and ways to achieve compliance. This mav affect, and therefore require corresponding changes and more emphasis, on certain areas in falsework design and their accompanying drawings and documentations.

(Some of the material used in this guideline courtesy of the Workers' Compensation Board of B.C.)

REGULATIONS

Engineers should familiarize themselves with the new Workplace Safety and Health Legislation respecting the Construction Industry (MR 189/85) to determine if the formwork/falsework involved requires the design by an engineer. The following types of concrete formwork and falsework require the provision at the jobsite of erection drawings and supplementary information signed and sealed by a professional engineer:

- flyforms
- gang forms
- slip forms
- suspended slab forms
- beam forms
- jump forms
- single-sided forms
- cantilever forms
- bridge deck forms
- shaft lining forms
- wall and column forms (of non-standard construction or non-standard height in conventional buildings)
- tunnel lining forms
- arch forms
- other types of formwork the failure of which could, in the opinion of a Safety and Health Officer, cause injury to a worker.

(See some samples, Appendix "C")

Some engineers may choose to design only the support falsework portion of a formwork system or a specific portion of the whole project. This must be made abundantly clear to contractors and so specified in all relevant drawings and documents. Statements such as "THIS IS NOT A FORMWORK DRAWING REQUIRED BY W.S.H. MR 189/85 SEC. 90" written in the large print on the drawing should prevent the possibility of any misunderstanding. Formwork design and drawings need not be submitted to the Division for approval or retention, but must be available if requested by a Safety and Health Officer.

A record of all inspections is essential to ensure compliance with the falsework formwork design as stipulated in section (91) of Manitoba Regulation 189/85.

All revisions and changes to the falsework drawing and specifications must be substantiated by the engineer authorizing the changes. The engineers should ensure that written authorization is available at the jobsite immediately, to be followed by proper documentation as

soon as practicable.

CODES AND STANDARDS:

CSA Standard S269.1-1975 deals only with falsework and specifically excludes forms. The practice of noting on the drawings: "Formwork is the responsibility of contractors" or "Blocking by others" is no longer acceptable under the new regulations. Formwork designers are expected to show details of forms and all associated connections, blocking, braces and ties that are necessary to ensure formwork integrity during erection and concrete placement.

The CSA Standards O86, S16, S157, A23.1, A23.3 will continue to provide the basis for formwork compliance. ACI SP4 and ACI Standard 347 are recommended as reference and guides for formwork designers.

Where there are discrepancies between the regulations and the standards, the overriding or qualifying requirements of the regulations prevail.

COORDINATION

- If two or more engineers are involved, each must check with the others to ensure that all aspects of the work are covered, and clearly understands everyone's respective responsibilities.

- The formwork design engineer must work very closely with the contractor and the crew whose knowledge, experience, preferences and equipment owned, dictate to a large extent the type of formwork to use, and how it is to be erected and used.

- The engineer must also consult the structural engineer regarding the formwork, construction load, shoring and reshoring, etc.

- Where tower cranes are used, care must be exercised to ensure adequate shoring around the crane mast openings so that all loads are transmitted to the structure/foundation safely.

DESIGN CONSIDERATIONS

- Although contractors are generally held responsible for workers' safety and the safety of partially assembled falsework/formwork structure and components, an engineer must, during the designing stage, give careful consideration to the effects on safety due to the choice of a particular design, equipment and methodology for the erection, use and dismantling of formworks and their sub-assemblies. Engineers must therefore compare the merits of the preferred design, equipment and methodology against all available alternatives prior to making their final decisions.

- Forms that require work platforms must have these included in the design drawings. The designer must take into consideration where the forms are going to be used, so that proper safety measures are included.

- The method, sequence and rate of pour must be specified, taking into consideration the ambient temperature and type of concrete used. This becomes more crucial for vertical pours, tunnel forms, etc., especially during cold weather.

- Many engineers choose to have joists extending excessively beyond the main beam or stringer supports, due to either the fixed width of shoring frames used, limiting deflection criteria, or limited equipment availability. Such excessive overhangs often cause the uplifting of the joists when subjected to loading during construction and/or concrete placement. Overhangs must therefore be kept as short as possible.

- Prior to using any pre-manufactured items, the engineer must ascertain that their capacities have previously been determined by proper analysis or tests as required by the CSA Standards. Such items must be properly identified in the drawing to enable accurate field assembly. Inability to provide such essential information by the equipment supplier or contractor justifies rejection of their use in the falsework/formwork system.

PROBLEM AREAS

- As rotation of joists and beams is one of the main causes of falsework collapses, the maximum permissible depth/width ratio, (which should be under 2.5 for unrestrained members) must be checked carefully. U-heads with wedges are desirable in all cases and their use is preferred whenever possible, so as to develop good restraint at bearing. Toe nailing alone at bearing offers little resistance against lateral rotation.

- Inadequate bracings, lacings or ties, and their connections to the main members, is another problem area which some engineers may overlook but often results in formwork failure. Details of such ties and their connections must be properly shown and specified in the drawings. The slenderness ration of all woodbracings, lacings, and ties should be kept below 50.

- Employers must give attention to mudsills, splicings and connections between members. When the specified items are not available, only approved and tested substitutes are to be used instead.

- Pre-manufactured items must be used with care, and only approved or tested substitutes must be used.

- Many collapses caused by instability associated with single post shores, especially those supporting beams with flat heads, the use of which should therefore be carefully scrutinized due to the inherent tendency of the supported beams to rotate under impact loads or vibrations. They must be properly restrained and braced to prevent movement..

- Shores sitting on ramps or supporting sloping slabs must be treated with great respect as improper wedging under or above such sloping members has been guilty of past failures.

- The requirements for flyforms are quite specific and are clearly stated in the regulations, sections 93 to 98. Engineers are urged to give due attention to inadvertent mix-ups, panel rotations, poor rigging arrangements and other field problems. The designer,

or another engineer designated by the designer, must witness the first flying cycle to ensure compliance with his instructions, and to rectify any unforeseen problems.

- The use of standard form multiples that require custom built filler sections demands careful specifications as to their exact constructions, locations and connections. Mistakes or mix-ups can easily take place in the field with disastrous consequences.

- Variation from plumb for vertical members varies considerably between engineers' specifications. Whenever possible, use the tolerances given in the CSA Standard Clause 7.2.6 of S269.1-1975.

STRIPPING, RESHORING - MR 189/86, Sec. 92

- Instructions regarding proper timing, sequence and method in form stripping for reshoring and for form removal should be specific and stated clearly, referencing the expected concrete strength, curing time and temperature, design load of structure, etc.

- Where reshoring is required, proper drawings and specific instructions must be provided instead of using such loose specifications as 70% or 50% reshoring, in note form. Reshoring plans should be submitted to the structural engineer of the permanent structure for consideration and acceptance.

Note: Refer to CSA S269.1, Clause 7.2.11 and ACI 347-78, Clause 3.6 and 3.7 for proper procedures in stripping and reshoring.

INSPECTION

- The employer/contractor must personally inspect the falsework/formwork prior to placing concrete. The inspection record must be issued only after the formwork has been completed in accordance with the design, and must not include a deficient list of items that still require further upgrading or changes. Inspection conducted 24 hours or less prior to pour is the general rule of thumb. All changes to the original design drawing must be signed and sealed by the engineer. A sample certificate is attached in Appendix "B".

APPENDIX "A"

COMMON CAUSES OF FORMWORK FAILURES

(FAILURE USUALLY DUE TO COMBINATION OF MORE THAN ONE FACTOR)

ROTATION OF STRINGERS, BEAMS OR JOISTS
DEFICIENT CONNECTIONS
INADEQUATE OR DEFECTIVE BRACING OR TIES
SINGLE POST SHORES (USUALLY WITH FLAT HEADS)
SHORES ON SLOPES OR SUPPORTING SLOPING SLABS
UNTESTED OR MISUSED PROPRIETARY COMPONENTS
UNAUTHORIZED VARIATIONS AND POOR WORK PRACTICES
DEFECTIVE EQUIPMENT
DIFFERENTIAL SETTLEMENT
CANTILEVER LOADING
VIBRATION & IMPACT
EXCESSIVE RATE OF POUR OR PLACING
IMPROPER SEQUENCE OF POUR OR PLACING
INADEQUATE DESIGN

Appendix "B"

FALSEWORK/FORMWORK INSPECTION

MR 189/85, Sec. 91

Date of Inspection _____ Time _____

Contractor _____ Office Tel. _____

_____

Project and Location _____ Site Tel. _____

_____ Superintendent _____

Date of Latest F/W Erection Drawing _____

_____

Formwork Area Inspected _____

_____

Reshoring in Place Applicable According to Design _____

_____

Remarks (Not to be used as a Deficiency List)

_____

_____

Scheduled Date of Concrete Placement _____

Concrete Curing Time Prior to Stripping and Reshoring _____

Certification:

This is to certify that in accordance with MR 189/85, sec. 91, the above noted formwork and reshores have been inspected and found to be substantially in accordance with the latest approved erection drawings and all supplementary information, and are ready for placement of concrete.

Inspected and Approved by:

_____
Name (Print)

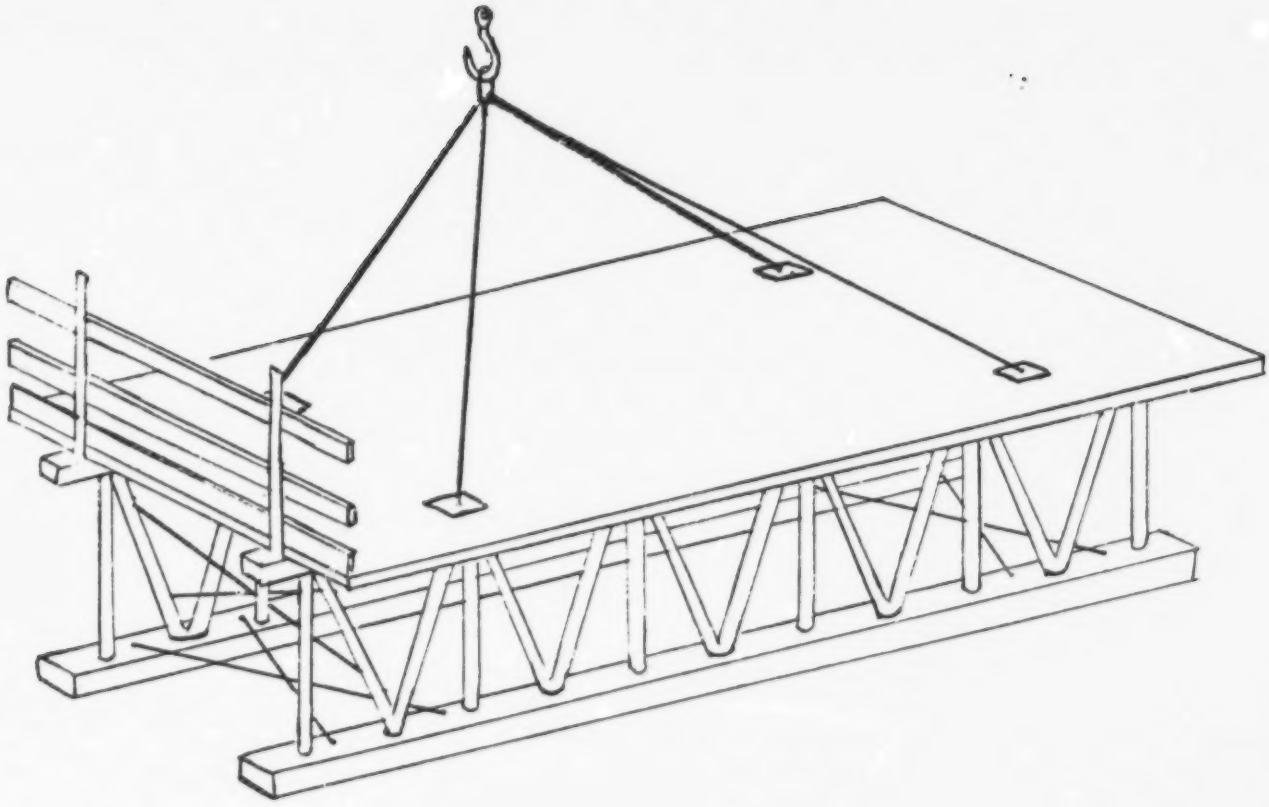
_____
Signature

_____
D a t e

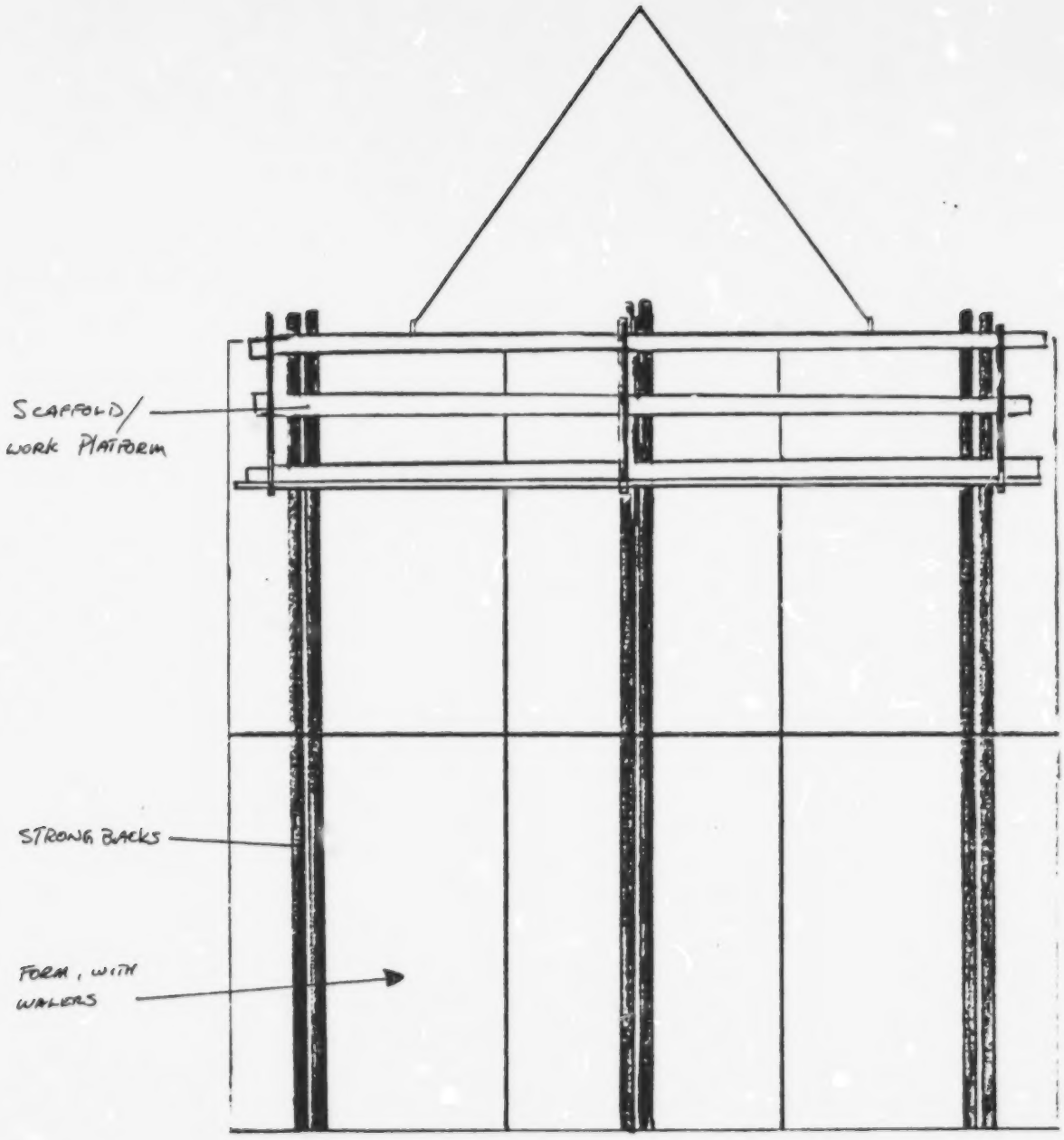
Appendix "C"

EXAMPLES OF FALSEWORK

FLYFORMS

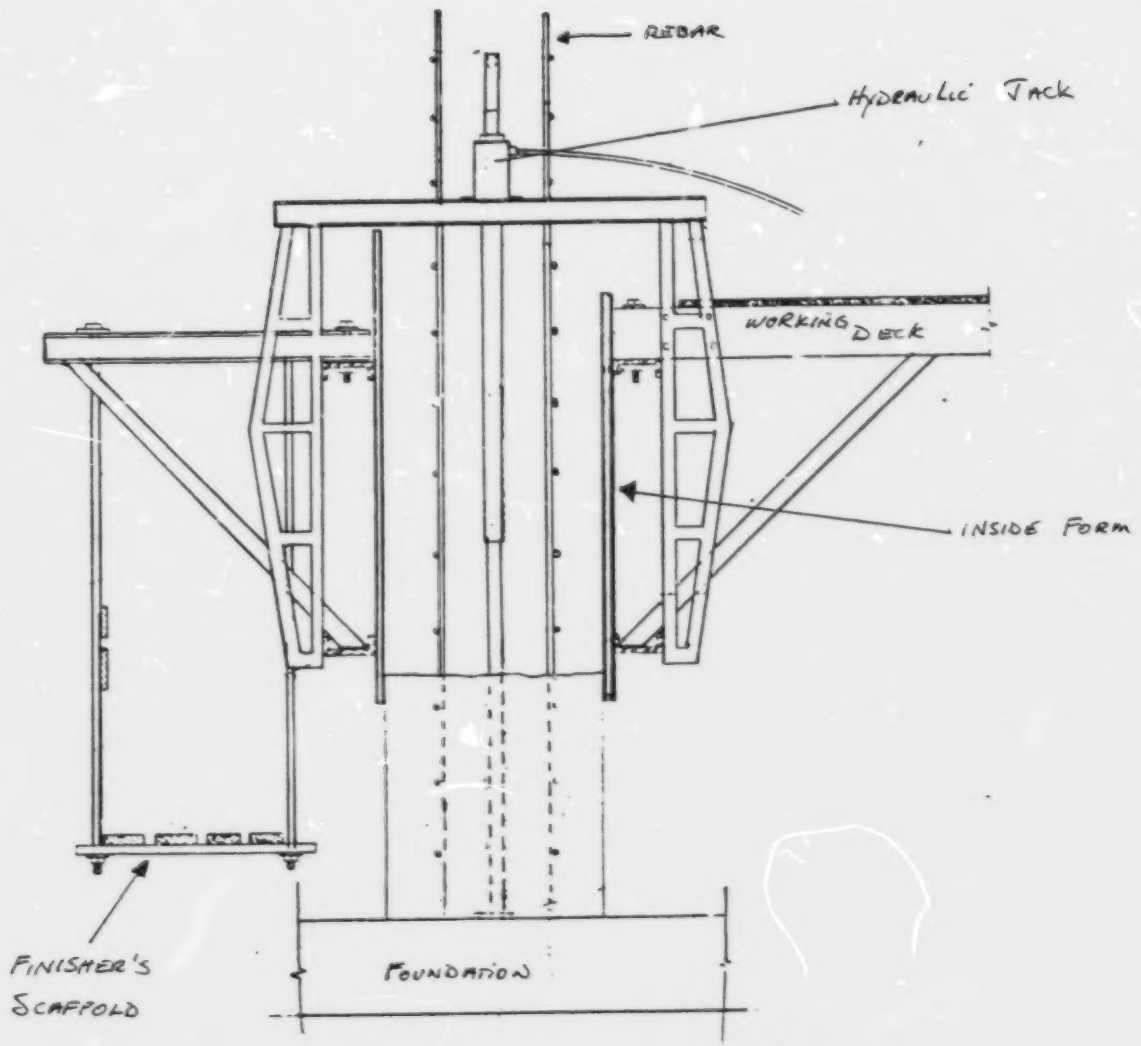


NOTE: Specific flyform regulations in MR 189/85, sections 93-98.

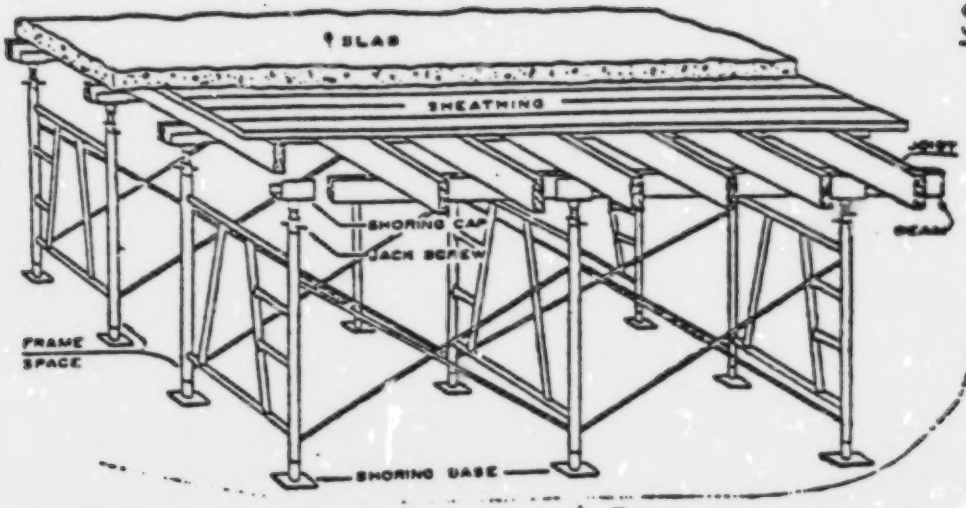


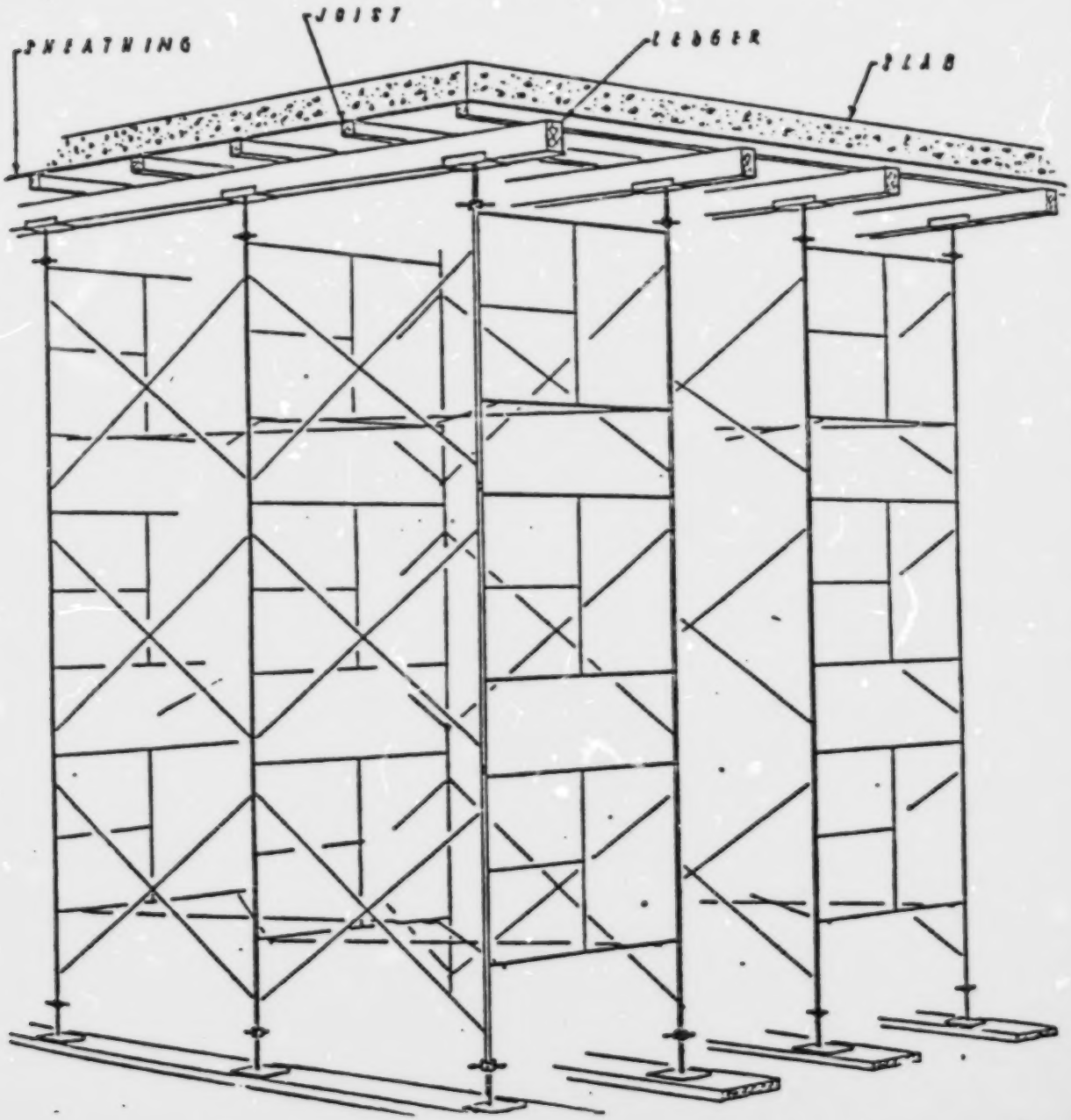
GANG FORMS

SLIP FORM

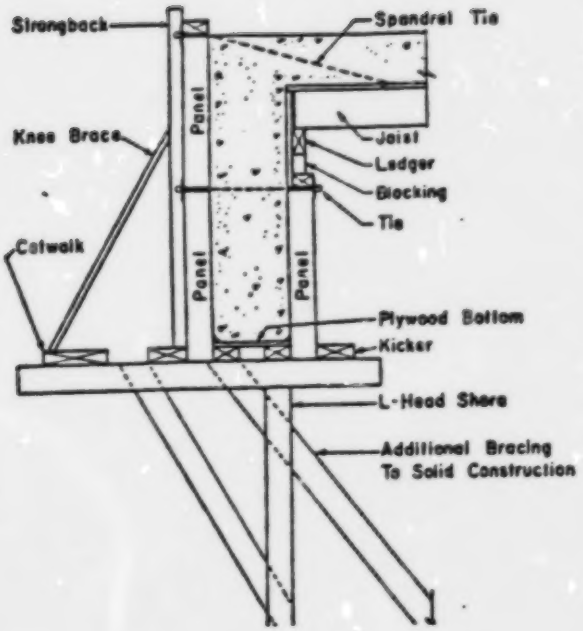

REBAR
HYDRAULIC JACK
WORKING DECK
INSIDE FORM
FINISHER'S SCAFFOLD
FOUNDATION

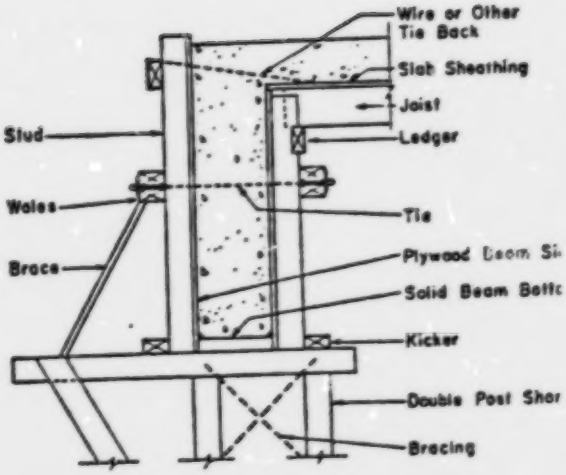
SUSPENDED SLAB FORMS

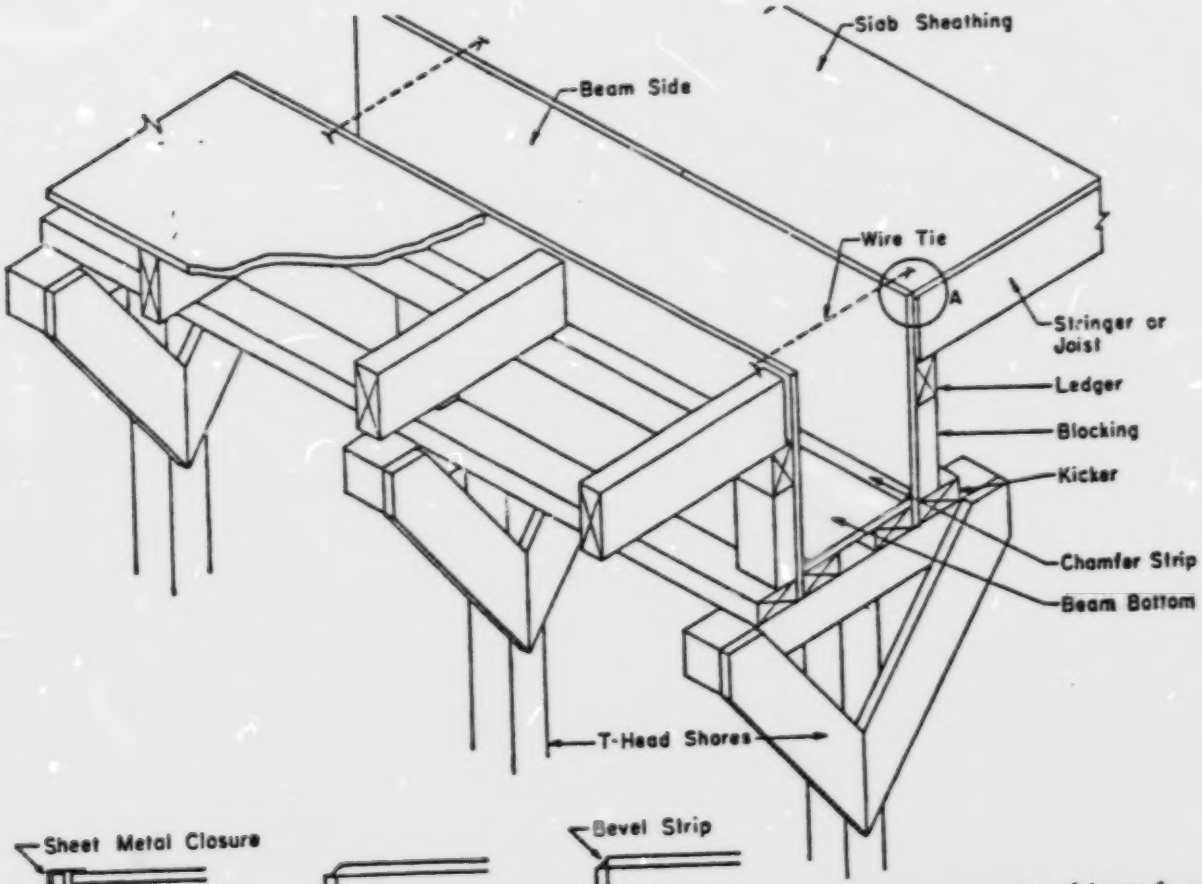


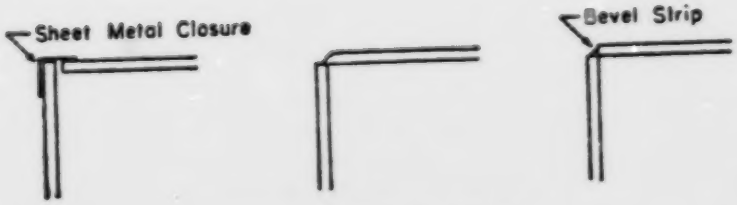


BEAM FORMS





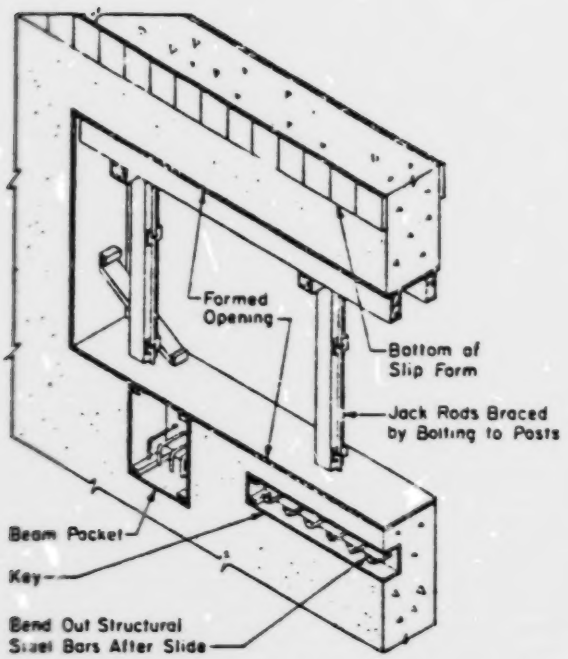




ALTERNATE DETAILS AT "A"

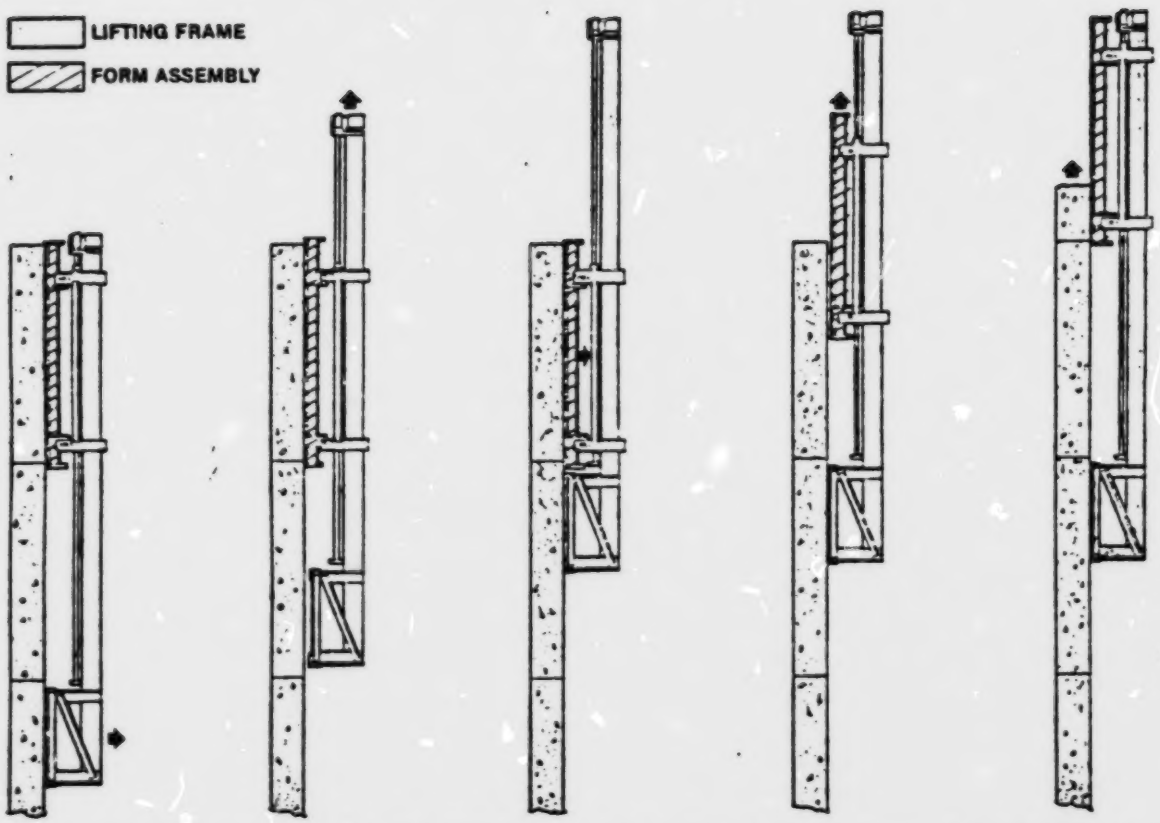
Typical components of beam formwork with slab framing in. Plywood is the sheathing material, and the beam bottom panel is backed with dimension lumber. Alternate details show different treatments of the form at beam-slab intersection.

HEADER FORMS



Typical forming details to allow for openings, beam pockets, concrete brackets, etc. Where jack rods extend through formed openings, bracing must be provided for their support.

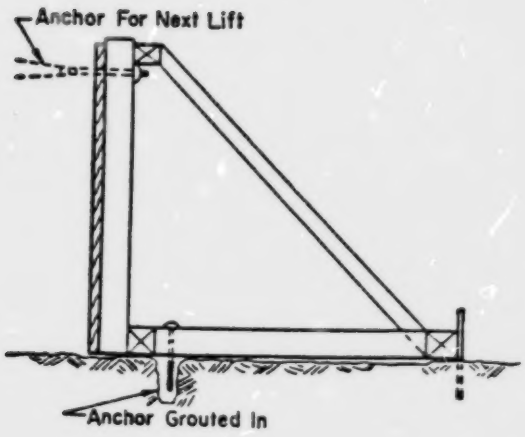
JUMP FORMS

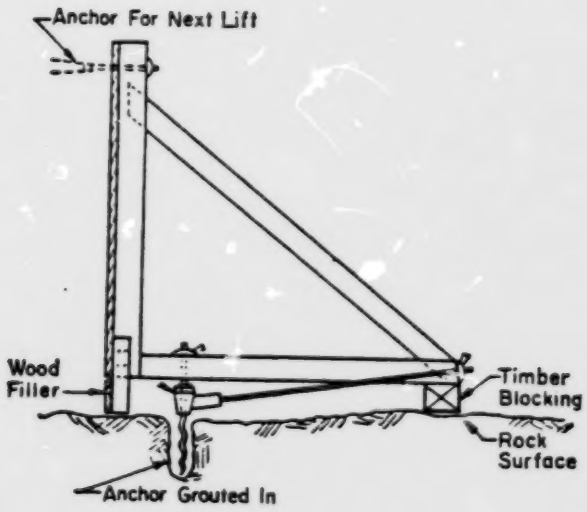


Schematic representation of lifting sequence for one type of electrically operated self-raising forms. In View 1 both form and lifting frame are against the wall, and concrete placed a little below the top of the form. View 2 shows frame pulled away from wall and partially raised. In View 3, frame has been refastened to the wall just below the form. In View 4, the form is retracted from the wall and partially raised. View 5 shows form back in operating position, with concrete placement started.

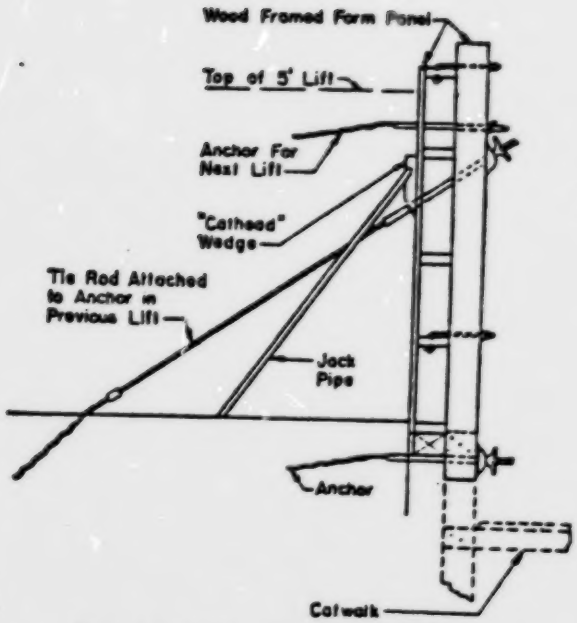
These simplified drawings show only the sequence of movement, and omit the ties, anchors, and working platforms required on the job. Conventional wall installation would have forms and lifters on two sides of the wall. Dam faces and metal-lined nuclear reactor containment structures may have only one set of forms. (Drawing adapted from information supplied by Blaw-Knox Equipment, Inc.)

SINGLE-SIDED FORMS

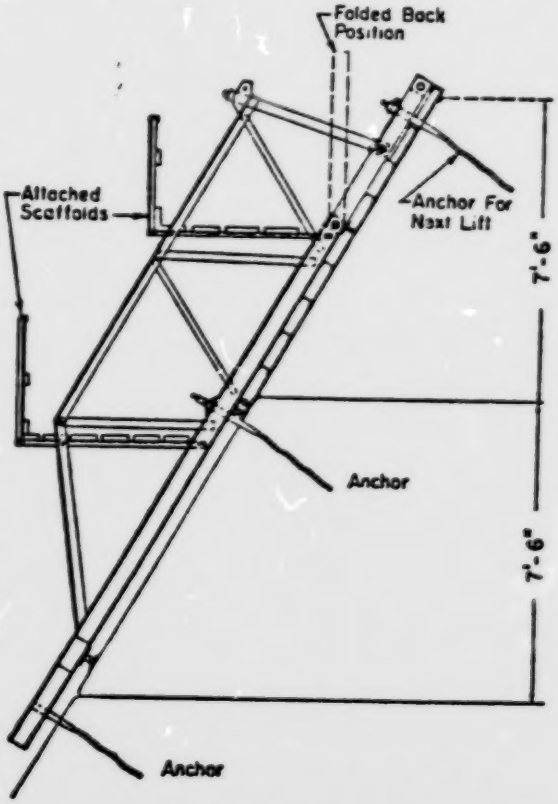




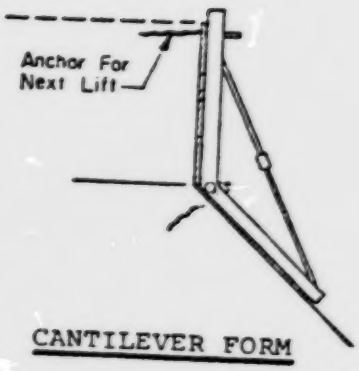
CANTILEVER FORMS (CONT.)



Vertical tied cantilever form for 5-ft lift. Jack pipe helps maintain alignment until concrete is placed.



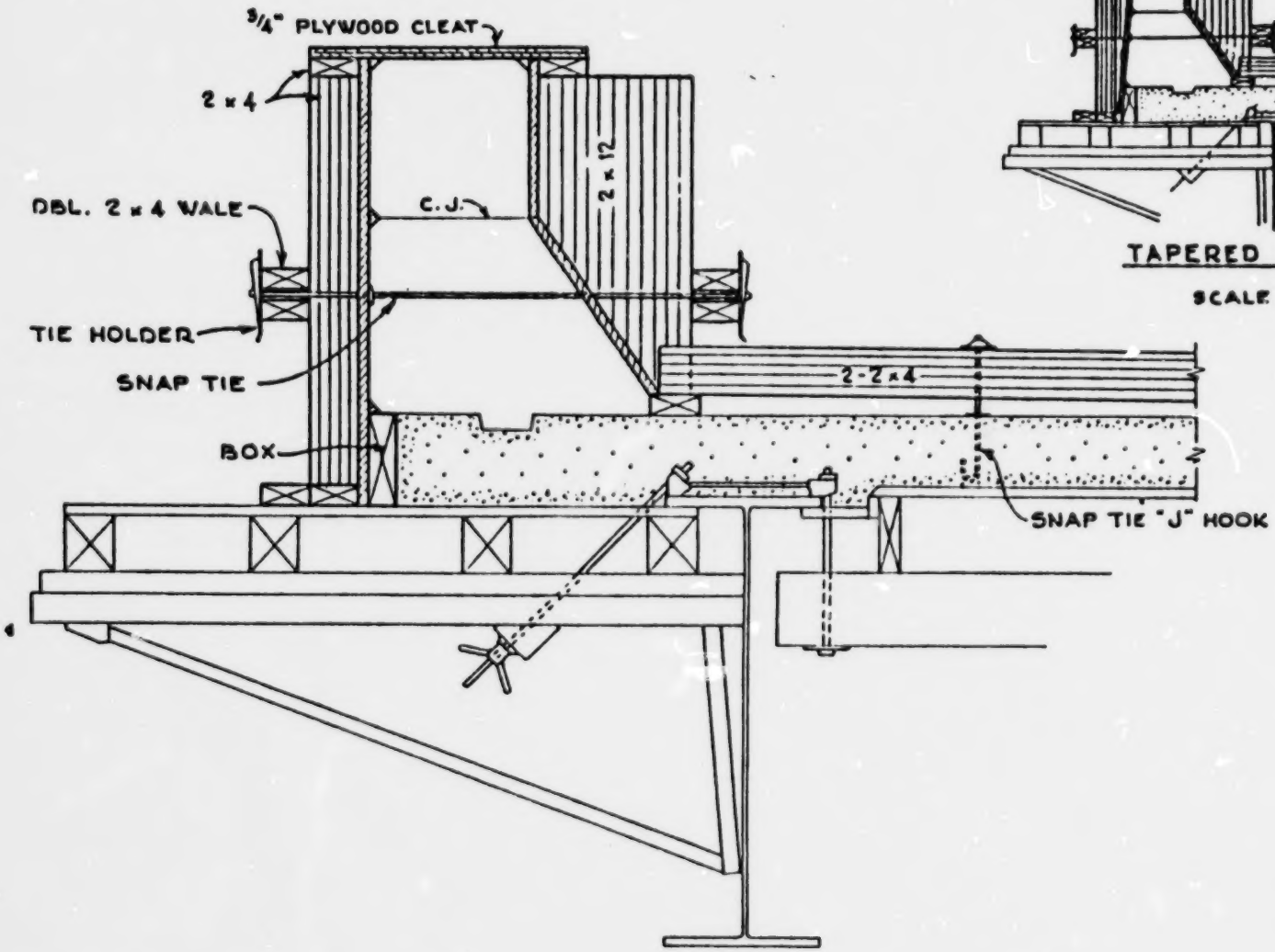
Hinged sloping cantilever form for 7½-ft lift, showing working scaffolds attached. Tilting upper portion of form makes it easier to place concrete near toe of slope.

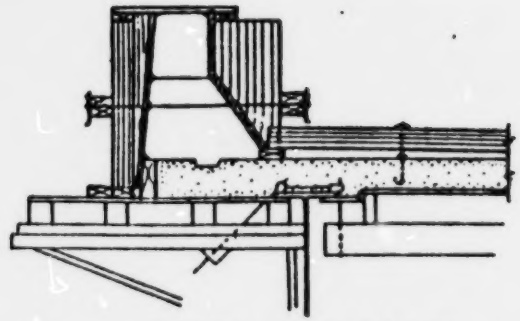


CANTILEVER FORM

Simplified sketch indicates adjustment of cantilever form for change of direction.

BRIDGE DECK PARAPET FORMING





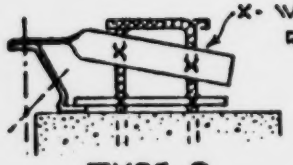
TAPERED PARAPET

SCALE 3/8" = 1'-0"

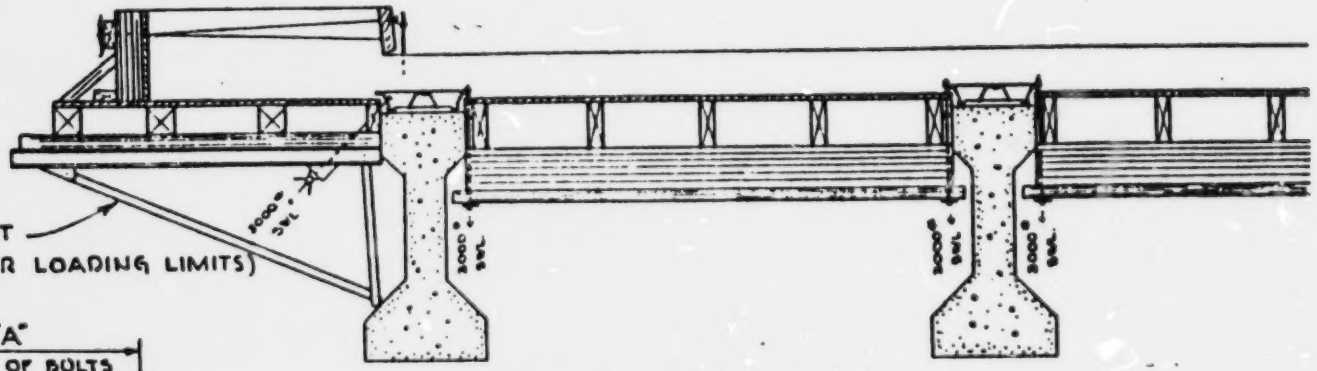
BRIDGE DECK FORMS

CON - BEAM HANGER

FOR CONCRETE BEAMS

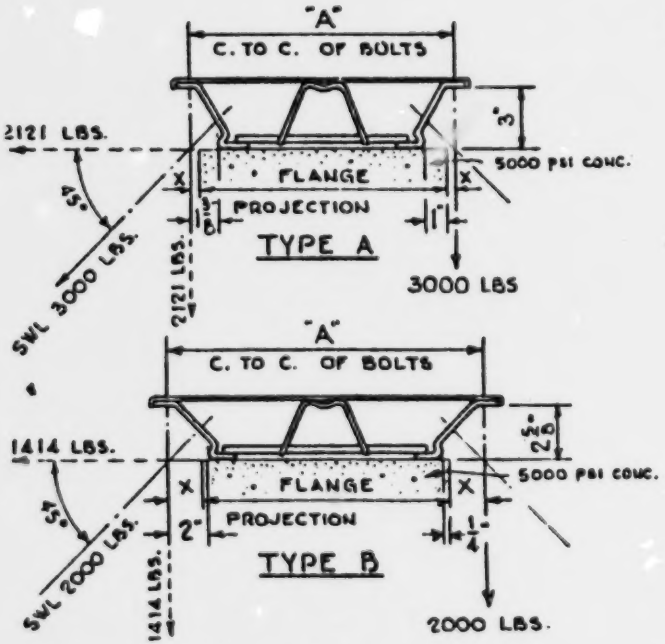


TYPE D

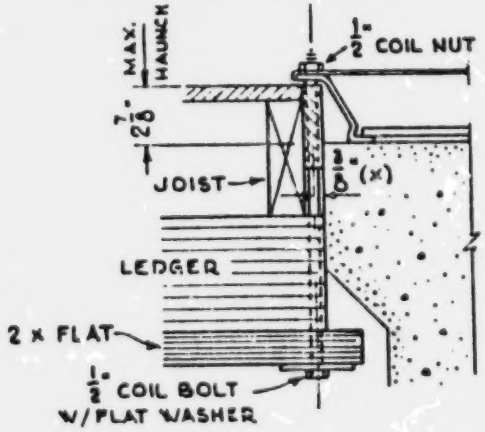


BRIDGE DECK SECTION

SHOWING GM CON-BEAM HANGERS

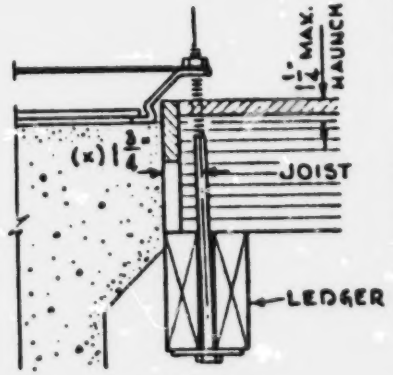


NOTE: DIMENSION "A" = FLANGE WIDTH PLUS 2 (x).



TYPE A HANGER

WITH LEDGER PERPENDICULAR TO BEAM

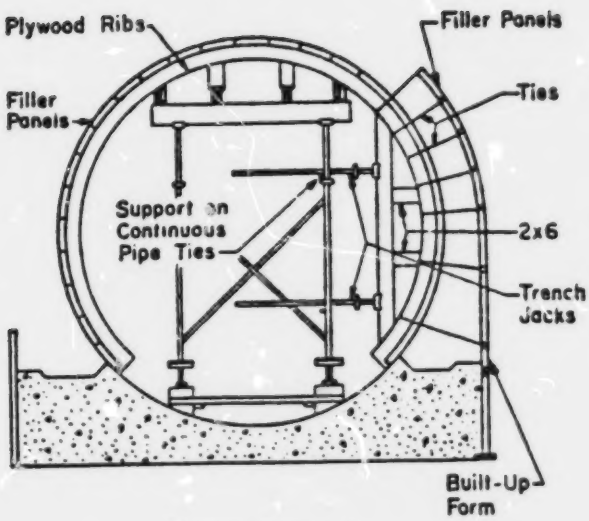


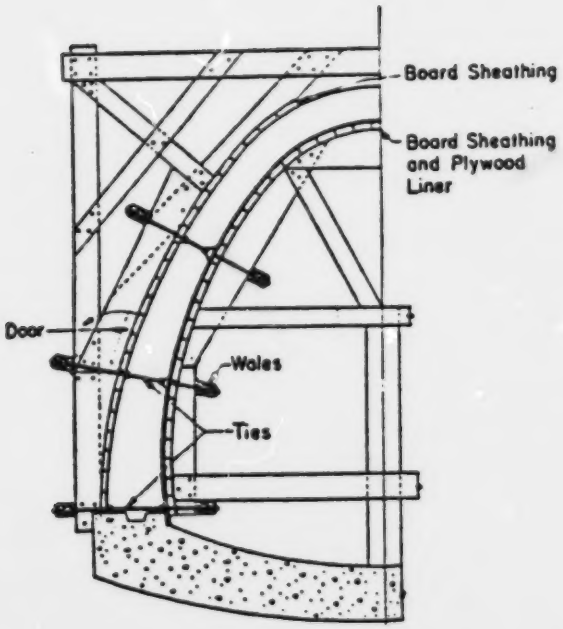
TYPE B HANGER

WITH LEDGER PARALLEL TO BEAM

BRIDGE DECK FORMS (CONT.)

ARCH FORMS


Plywood Ribs
Filler Panels
Filler Panels
Ties
Support on Continuous Pipe Ties
2x6
Trench Jacks
Built-Up Form


Board Sheathing
Board Sheathing and Plywood Liner
Door
Wales
Ties

TUNNEL LINING FORMS